

CLAIMS

I claim:

1. A method for calculating an at least one effect of a plurality of environmental conditions on an animal, comprising:
 - providing a data set of the plurality of environmental conditions for an at least one locality during an at least one time interval;
 - providing a data set of characteristics of the animal;
 - translating the set of environmental conditions data into a set of microclimate conditions experienced by the animal, by running a microclimate model to generate values for the set of microclimate conditions using the set of environmental conditions data and the set of animal characteristics data, the microclimate model comprising a solar radiation model to enable the calculation of an input of solar radiation when the sun is above the horizon and when the sun is below the horizon; and,
 - solving for a set of animal conditions by running an animal model using the set of microclimate conditions and the set of animal characteristics, for each of the at least one time intervals at each of the at least one localities, the set of animal conditions comprising an amount of discretionary energy and an amount of discretionary water available to the animal, and a total activity time of the animal.
2. The method of Claim 1, further comprising storing the set of animal conditions data in an animal conditions database.
3. The method of Claim 2, further comprising calculating an at least one user-specifiable variable using the data stored in the animal conditions database.

4. The method of Claim 3, wherein the at least one user-specifiable variable comprises a reproductive potential of the animal calculated by using the amounts of discretionary energy and water available to the animal.

5. The method of Claim 3, wherein the at least one user-specifiable variable comprises a growth potential of the animal calculated by using the amounts of discretionary energy and water available to the animal.

6. The method of Claim 3, wherein the at least one user-specifiable variable comprises a mortality rate of the animal calculated by using the total activity time of the animal.

7. The method of Claim 3, wherein the at least one user-specifiable variable comprises an optimal body size of the animal for the at least one locality and for the at least one time interval.

8. The method of Claim 1, further comprising displaying the set of animal conditions data.

9. The method of Claim 8, wherein displaying the set of animal conditions comprises plotting the set of animal conditions by locality to analyze a spatial variation in the animal conditions.

10. The method of Claim 1, wherein running the animal model comprises:

calculating an amount of metabolic heat generation required to maintain a core temperature of the animal and noting an activity state of the animal, by performing a heat balance analysis, the activity state being chosen from the group consisting of active and non-active;

calculating the amount of discretionary energy available to the animal and the amount of discretionary water available to the animal by performing a mass balance analysis using the calculated amount of metabolic heat generation; and,

calculating the total activity time of the animal by summing the at least one time intervals at which the activity state of the animal was noted to be active.

11. The animal model of Claim 10, wherein performing the heat balance analysis comprises:

computing an amount of solar radiation absorbed by the animal;

estimating the amount of metabolic heat generation required to maintain the core temperature of the animal;

computing a skin temperature of the animal using the estimated amount of metabolic heat generation and the computed amount of solar radiation absorbed by the animal;

calculating a plurality of heat fluxes between the animal and its environment and calculating a net heat exchange for the animal;

solving a heat balance equation to compute an error value;

if the error value is greater than a pre-specified maximum value, repeating the previous steps from the estimating the amount of metabolic heat generation step to the current step;

if the error value is less than or equal to the pre-specified maximum value, running a thermoregulatory model comprising;

computing a core-skin temperature differential as the difference between the core temperature of the animal and the skin

temperature of the animal and comparing the core-skin
temperature differential to a pre-specified minimum value;
if the core-skin differential is less than the pre-specified minimum
value, exercising an option in a hierarchy of behavioral and
physiological options, and repeating the previous steps from the
estimating the amount of metabolic heat generation step to the
computing a core-skin temperature differential step; and,
if the core-skin differential is greater than or equal to the pre-specified
minimum value, setting the calculated value for metabolic heat
generation equal to the estimated value of the amount of
metabolic heat generation.

12. The method of Claim 11, wherein the calculating a plurality of heat fluxes comprises
running a porous media model for insulation.

13. The method of Claim 12, wherein the porous media model comprises a solar radiation
component to calculate an amount of solar radiation absorbed by the animal.

14. The method of Claim 12, wherein the porous media model further comprises an
appendage model to calculate an amount of heat exchange at an at least one appendage
of the animal.

15. The method of Claim 10, wherein performing the mass balance analysis comprises
running a gut model coupled to a lung model.

16. The mass balance analysis of Claim 15, further comprising running a skin subroutine to calculate an amount of water loss by evaporation at the skin of the animal.

17. The method of Claim 1, wherein each of the at least one localities is defined by a set of geographic coordinates.

18. The method of Claim 1, wherein the at least one time intervals comprise hours, days, months and a year.

19. The method of Claim 1, wherein the data set of environmental conditions comprises data provided by an environmental conditions database.

20. The method of Claim 19, wherein the data set of environmental conditions further comprises data provided by a user.

21. The method of Claim 20, wherein the data provided by a user comprises a specification of the at least one locality and the at least one time interval.

22. The method of Claim 1, wherein the data set of environmental conditions comprise a temperature, a rainfall amount, a wind velocity and direction, and a solar and infrared radiation at each of the at least one localities for at least one of the at least one time intervals.

23. The method of Claim 22, wherein the data set of environmental conditions further comprises a soil type, a slope of the terrain and an aspect of the terrain at each of the at least one localities.

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24. The method of Claim 23, wherein the set of microclimate conditions comprises a temperature profile as a function of the slope of the terrain.

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25. The method of Claim 22, wherein the set of environmental conditions further comprises a type and abundance of plant cover.

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26. The method of Claim 25, wherein the set of microclimate conditions comprises a temperature profile as a function of the type and abundance of plant cover.

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27. The method of Claim 25, wherein the set of microclimate conditions comprises a wind profile as a function of the type and abundance of plant cover.

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28. The method of Claim 1, wherein the set of microclimate conditions experienced by the animal comprise a clear sky solar radiation, an infrared fluxes from the sky and ground, and a temperature, a velocity and a relative humidity of air passing over the animal at an average height of the animal above ground, and a percentage of thermally available habitat.

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29. The method of Claim 1, wherein the data set of animal characteristics comprises data on a body allometry, a physiology and a morphology of the animal.

30. The method of Claim 29, wherein the data on the animal's body allometry comprise a body weight, a body dimensions and a body geometry of the animal.

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31. The method of Claim 29, wherein the data on the animal's physiology comprise a core temperature of the animal.

10 32. The method of Claim 29, wherein the data on the animal's morphology comprise a mean length of fibers, a fiber density per depth, a fiber diameter, a depth of insulation, a solar reflectivity of fibers, and a transmissivity of fibers.

15 33. The method of Claim 1, wherein the data set of animal characteristics comprises data provided by an animal characteristics database.

20 34. The method of Claim 1, wherein the data set of animal characteristics further comprises data provided by a user.

25 35. The method of Claim 34, wherein the data provided by a user comprises a diet, a preferred temperature range and an average height above ground of the animal.

30 36. A method for calculating an at least one effect of a plurality of environmental conditions on an animal, comprising:
 providing a data set of the plurality of environmental conditions for an at least
 one locality during an at least one time interval;
 providing a data set of characteristics of the animal;

translating the set of environmental conditions data into a set of microclimate conditions experienced by the animal, by running a microclimate model to generate values for the set of microclimate conditions using the set of environmental conditions data and the set of animal characteristics data; and,

solving for a set of animal conditions by running an animal model using the set of microclimate conditions and the set of animal characteristics, for each of the at least one time intervals at each of the at least one localities, the set of animal conditions comprising an amount of discretionary energy and an amount of discretionary water available to the animal, and a total activity time of the animal, the running of the animal model, comprising:

calculating an amount of metabolic heat generation required to maintain a core temperature of the animal and noting an activity state of the animal, by performing a heat balance analysis, the activity state being chosen from the group consisting of active and non-active;

calculating the amount of discretionary energy available to the animal and the amount of discretionary water available to the animal by performing a mass balance analysis using the calculated amount of metabolic heat generation, performing the mass balance analysis comprising running a gut model coupled to a lung model; and,

calculating the total activity time of the animal by summing the at least one time intervals at which the activity state of the animal was noted to be active.

37. The mass balance analysis of Claim 36, further comprising running a skin subroutine to calculate an amount of water loss by evaporation at the skin of the animal.

38. The method of Claim 36, further comprising storing the set of animal conditions data in an animal conditions database.

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39. The method of Claim 38, further comprising calculating an at least one user-specifiable variable using the data stored in the animal conditions database.

10 40. The method of Claim 39, wherein the at least one user-specifiable variable comprises a reproductive potential of the animal calculated by using the amounts of discretionary energy and water available to the animal.

15 41. The method of Claim 39, wherein the at least one user-specifiable variable comprises a growth potential of the animal calculated by using the amounts of discretionary energy and water available to the animal.

20 42. The method of Claim 39, wherein the at least one user-specifiable variable comprises a mortality rate of the animal calculated by using the total activity time of the animal.

25 43. The method of Claim 39, wherein the at least one user-specifiable variable comprises an optimal body size of the animal for the at least one locality and for the at least one time interval.

30 44. The method of Claim 36, further comprising displaying the set of animal conditions data.

45. The method of Claim 44, wherein displaying the set of animal conditions comprises plotting the set of animal conditions by locality to analyze a spatial variation in the animal conditions.

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46. The method of Claim 36, wherein the microclimate model comprises a solar radiation model to enable the calculation of an input of solar radiation when the sun is above the horizon and when the sun is below the horizon.

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47. The animal model of Claim 36, wherein performing the heat balance analysis comprises:

- computing an amount of solar radiation absorbed by the animal;
- estimating the amount of metabolic heat generation required to maintain the core temperature of the animal;
- computing a skin temperature of the animal using the estimated amount of metabolic heat generation and the computed amount of solar radiation absorbed by the animal;
- calculating a plurality of heat fluxes between the animal and its environment and calculating a net heat exchange for the animal;
- solving a heat balance equation to compute an error value;
- if the error value is greater than a pre-specified maximum value, repeating the previous steps from the estimating the amount of metabolic heat generation step to the current step;
- if the error value is less than or equal to the pre-specified maximum value, running a thermoregulatory model comprising:
 - computing a core-skin temperature differential as the difference between the core temperature of the animal and the skin temperature of the animal and comparing the core-skin temperature differential to a pre-specified minimum value;

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if the core-skin differential is less than the pre-specified minimum value, exercising an option in a hierarchy of behavioral and physiological options, and repeating the previous steps from the estimating the amount of metabolic heat generation step to the computing a core-skin temperature differential step; and,
if the core-skin differential is greater than or equal to the pre-specified minimum value, setting the calculated value for metabolic heat generation equal to the estimated value of the amount of metabolic heat generation.

48. The method of Claim 47, wherein the calculating a plurality of heat fluxes comprises running a porous media model for insulation.

49. The method of Claim 48, wherein the porous media model comprises a solar radiation component to calculate an amount of solar radiation absorbed by the animal.

50. The method of Claim 48, wherein the porous media model further comprises an appendage model to calculate an amount of heat exchange at an at least one appendage of the animal.

51. The method of Claim 36, wherein each of the at least one localities is defined by a set of geographic coordinates.

52. The method of Claim 36, wherein the at least one time intervals comprise hours, days, months and a year.

53. The method of Claim 36, wherein the data set of environmental conditions comprises data provided by an environmental conditions database.

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54. The method of Claim 55, wherein the data set of environmental conditions further comprises data provided by a user.

10 55. The method of Claim 54, wherein the data provided by a user comprises a specification of the at least one locality and the at least one time interval.

15 56. The method of Claim 36, wherein the data set of environmental conditions comprise a temperature, a rainfall amount, a wind velocity and direction, and a solar and infrared radiation at each of the at least one localities for at least one of the at least one time intervals.

20 57. The method of Claim 56, wherein the data set of environmental conditions further comprises a soil type, a slope of the terrain and an aspect of the terrain at each of the at least one localities.

25 58. The method of Claim 57, wherein the set of microclimate conditions comprises a temperature profile as a function of the slope of the terrain.

30 59. The method of Claim 57, wherein the set of environmental conditions further comprises a type and abundance of plant cover.

60. The method of Claim 59, wherein the set of microclimate conditions comprises a temperature profile as a function of the type and abundance of plant cover.

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61. The method of Claim 59, wherein the set of microclimate conditions comprises a wind profile as a function of the type and abundance of plant cover.

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62. The method of Claim 36, wherein the set of microclimate conditions experienced by the animal comprise a clear sky solar radiation, an infrared fluxes from the sky and ground, and a temperature, a velocity and a relative humidity of air passing over the animal at an average height of the animal above ground, and a percentage of thermally available habitat.

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63. The method of Claim 36, wherein the data set of animal characteristics comprises data on a body allometry, a physiology and a morphology of the animal.

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64. The method of Claim 63, wherein the data on the animal's body allometry comprise a body weight, a body dimensions and a body geometry of the animal.

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65. The method of Claim 63, wherein the data on the animal's physiology comprise a core temperature of the animal.

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66. The method of Claim 63, wherein the data on the animal's morphology comprise a mean length of fibers, a fiber density per depth, a fiber diameter, a depth of insulation, a solar reflectivity of fibers, and a transmissivity of fibers.

67. The method of Claim 36, wherein the data set of animal characteristics comprises data provided by an animal characteristics database.

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68. The method of Claim 36, wherein the data set of animal characteristics further comprises data provided by a user.

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69. The method of Claim 68, wherein the data provided by a user comprises a diet, a preferred temperature range and an average height above ground of the animal.

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70. A method for calculating an at least one effect of a plurality of microclimate conditions on an animal, comprising:

providing a data set of the plurality of microclimate conditions for an at least one locality during an at least one time interval;

providing a data set of characteristics of the animal;

solving for a set of animal conditions by running an animal model using the set of microclimate conditions and the set of animal characteristics, for each of the at least one time intervals at each of the at least one localities, the set of animal conditions comprising an amount of discretionary energy and an amount of discretionary water available to the animal, and a total activity time of the animal, the running of the animal model, comprising:

calculating an amount of metabolic heat generation required to

maintain a core temperature of the animal and noting an activity state of the animal, by performing a heat balance analysis, the activity state being chosen from the group consisting of active and non-active;

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calculating the amount of discretionary energy available to the animal
and the amount of discretionary water available to the animal by
performing a mass balance analysis using the calculated amount
of metabolic heat generation, the performing the mass balance
analysis comprising running a gut model coupled to a lung
model; and,
calculating the total activity time of the animal by summing the at least
one time intervals at which the activity state of the animal was
noted to be active.

71. The mass balance analysis of Claim 70, further comprising running a skin subroutine
to calculate an amount of water loss by evaporation at the skin of the animal.

72. The method of Claim 70, further comprising storing the set of animal conditions data
in an animal conditions database.

73. The method of Claim 70, further comprising calculating an at least one user-
specifiable variable using the data stored in the animal conditions database.

74. The method of Claim 70, wherein the at least one user-specifiable variable comprises
a reproductive potential of the animal calculated by using the amounts of discretionary
energy and water available to the animal.

75. The method of Claim 70, wherein the at least one user-specifiable variable comprises
a growth potential of the animal calculated by using the amounts of discretionary
energy and water available to the animal.

76. The method of Claim 70, wherein the at least one user-specifiable variable comprises a mortality rate of the animal calculated by using the total activity time of the animal.

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77. The method of Claim 70, wherein the at least one user-specifiable variable comprises an optimal body size of the animal for the at least one locality and for the at least one time interval.

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78. The method of Claim 70, further comprising displaying the set of animal conditions data.

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79. The method of Claim 70, wherein displaying the set of animal conditions comprises plotting the set of animal conditions by locality to analyze a spatial variation in the animal conditions.

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80. The animal model of Claim 70, wherein performing the heat balance analysis comprises:

computing an amount of solar radiation absorbed by the animal;

estimating the amount of metabolic heat generation required to maintain the
core temperature of the animal;

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computing a skin temperature of the animal using the estimated amount of
metabolic heat generation and the computed amount of solar radiation
absorbed by the animal;

calculating a plurality of heat fluxes between the animal and its environment
and calculating a net heat exchange for the animal;

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solving a heat balance equation to compute an error value;

if the error value is greater than a pre-specified maximum value, repeating the previous steps from the estimating the amount of metabolic heat generation step to the current step;

if the error value is less than or equal to the pre-specified maximum value,
5 running a thermoregulatory model comprising;

computing a core-skin temperature differential as the difference
between the core temperature of the animal and the skin
temperature of the animal and comparing the core-skin
temperature differential to a pre-specified minimum value;

10 if the core-skin differential is less than the pre-specified minimum
value, exercising an option in a hierarchy of behavioral and
physiological options, and repeating the previous steps from the
estimating the amount of metabolic heat generation step to the
computing a core-skin temperature differential step; and,

15 if the core-skin differential is greater than or equal to the pre-specified
minimum value, setting the calculated value for metabolic heat
generation equal to the estimated value of the amount of
metabolic heat generation.

20 81. The method of Claim 80, wherein the calculating a plurality of heat fluxes comprises
running a porous media model for insulation.

25 82. The method of Claim 81, wherein the porous media model comprises a solar radiation
component to calculate an amount of solar radiation absorbed by the animal.

30 83. The method of Claim 81, wherein the porous media model further comprises an
appendage model to calculate an amount of heat exchange at an at least one appendage
of the animal.

84. The method of Claim 70, wherein each of the at least one localities is defined by a set of geographic coordinates.

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85. The method of Claim 70, wherein the at least one time intervals comprise hours, days, months and a year.

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86. The method of Claim 70, wherein the set of microclimate conditions experienced by the animal comprise a clear sky solar radiation, an infrared fluxes from the sky and ground, and a temperature, a velocity and a relative humidity of air passing over the animal at an average height of the animal above ground, and a percentage of thermally available habitat.

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87. The method of Claim 70, wherein the data set of animal characteristics comprises data on a body allometry, a physiology and a morphology of the animal.

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88. The method of Claim 87, wherein the data on the animal's body allometry comprise a body weight, a body dimensions and a body geometry of the animal.

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89. The method of Claim 87, wherein the data on the animal's physiology comprise a core temperature of the animal.

90. The method of Claim 87, wherein the data on the animal's morphology comprise a mean length of fibers, a fiber density per depth, a fiber diameter, a depth of insulation, a solar reflectivity of fibers, and a transmissivity of fibers.

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91. The method of Claim 70, wherein the data set of animal characteristics comprises data provided by an animal characteristics database.

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92. The method of Claim 91, wherein the data set of animal characteristics further comprises data provided by a user.

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93. The method of Claim 92, wherein the data provided by a user comprises a diet, a preferred temperature range and an average height above ground of the animal.

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94. A method for calculating an at least one effect of a plurality of environmental conditions on an animal, comprising:

providing an at least one server computer in communication with a computer network;

providing input to the server comprising the plurality of environmental conditions data and a plurality of animal characteristics data;

processing the plurality of environmental conditions data and the plurality of animal characteristics data by the server, comprising:

translating the plurality of environmental conditions into a plurality of microclimate conditions experienced by the animal, by running a microclimate model;

solving for a set of animal conditions, by running an animal model using the set of microclimate conditions and the set of animal characteristics; and,

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generating output from the server, comprising the set of animal conditions.

95. A method for calculating an at least one effect of a plurality of environmental conditions on an animal, comprising:

providing at least one server computer in communication with a computer network, the at least one server computer hosting a microclimate model and an animal model, and providing a graphical user interface whereby a user may input conditions for use by the microclimate and animal models;

providing input to the server comprising the plurality of environmental conditions data and a plurality of animal characteristics data;

processing the plurality of environmental conditions data and the plurality of animal characteristics data by the server, comprising:

translating the plurality of environmental conditions into a plurality of microclimate conditions experienced by the animal, by running the microclimate model;

solving for a set of animal conditions, by running the animal model using data from the set of microclimate conditions and the set of animal characteristics; and,

generating output from the server, comprising the set of animal conditions.

96. A method for calculating an at least one effect of a plurality of environmental conditions on an animal, comprising:

providing at least one server computer in communication with a computer network, the at least one server computer hosting a microclimate model and an animal model, and providing a graphical user interface whereby a user may input conditions for use by the microclimate and animal models;

providing input to the server comprising the plurality of environmental
conditions data and a plurality of animal characteristics data;
processing the plurality of environmental conditions data and the plurality of
animal characteristics data by the server, comprising:
5 translating the plurality of environmental conditions into a plurality of
microclimate conditions experienced by the animal, by running
the microclimate model;
solving for a set of animal conditions, by running the animal model
using data from the set of microclimate conditions and the set of
10 animal characteristics;
generating output from the server, comprising the set of animal
conditions; and,
displaying output from the server to the user via the graphical user
interface.

97. A system to enable the calculation of an at least one effect of a plurality of
environmental conditions on an animal, comprising:

an at least one server computer in communication with a computer network,
20 the at least one server computer hosting a microclimate model
computer program and an animal model computer program, and
providing a graphical user interface whereby a user may input
conditions for use by the microclimate and animal model computer
programs; and,

25 a data store device to store output from the animal model computer program,
including the at least one effect of the plurality of environmental
conditions on the animal.

30 98. The at least one server computer of Claim 97, further hosting:

